Factory Automated Ground Vehicle (AGV) Safety

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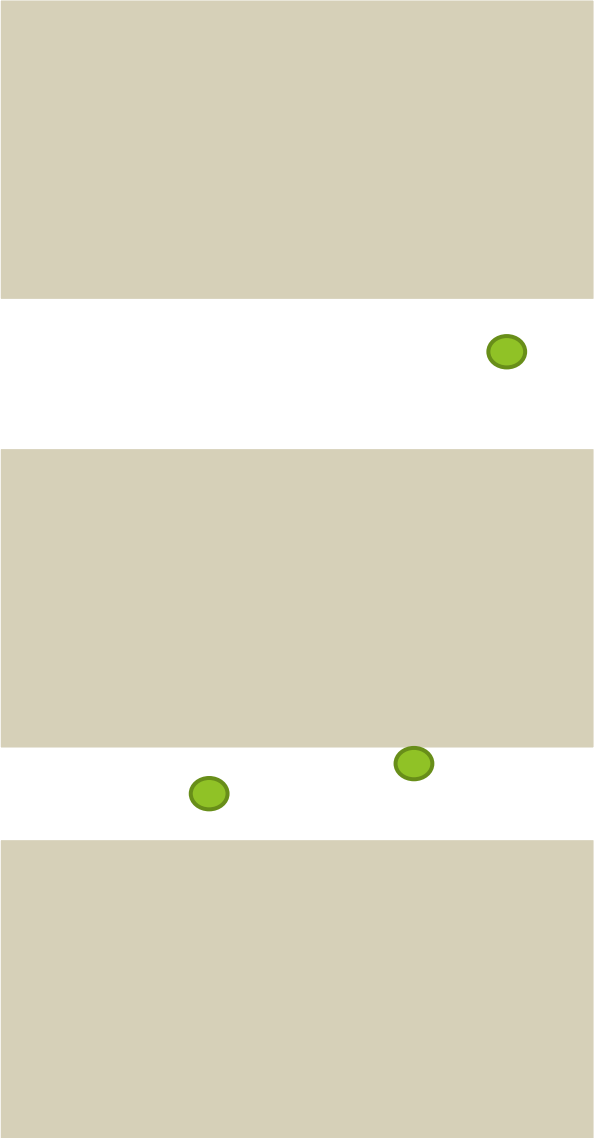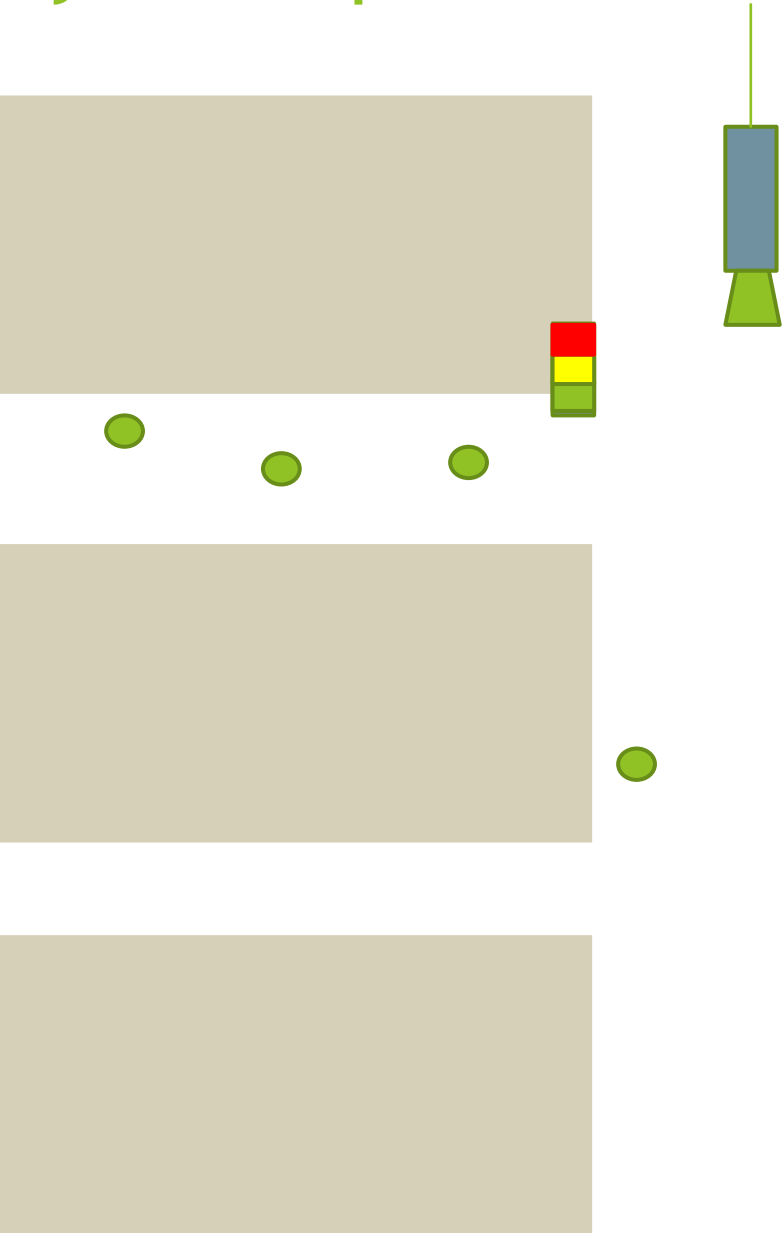
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The AGV Problem in the Factory

People can't see the AGV coming around blind corners

AGV when fully loaded and at full speed may not be capable of stopping in time to prevent collisions with people, parts and building structures (Sensors had less range than stopping distance)
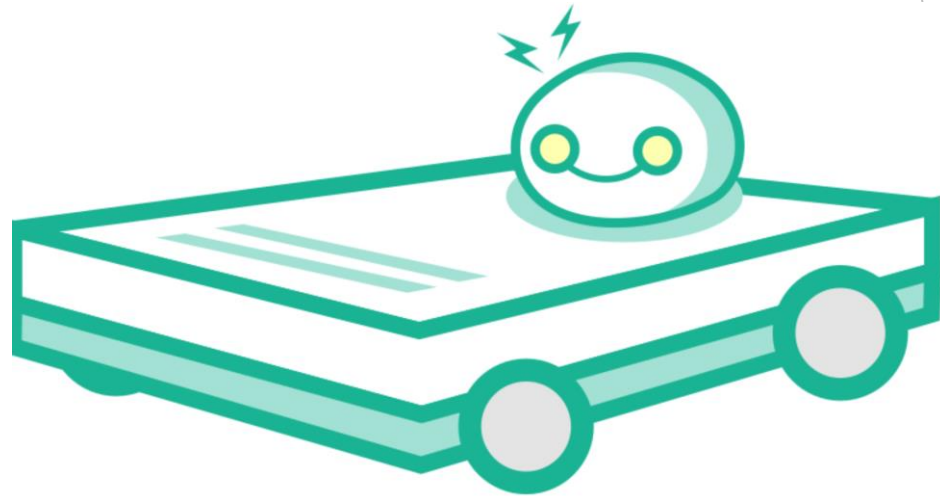
Early Concept

Solution 1: Put up a stop light

Puts the responsibility on people instead of on the system

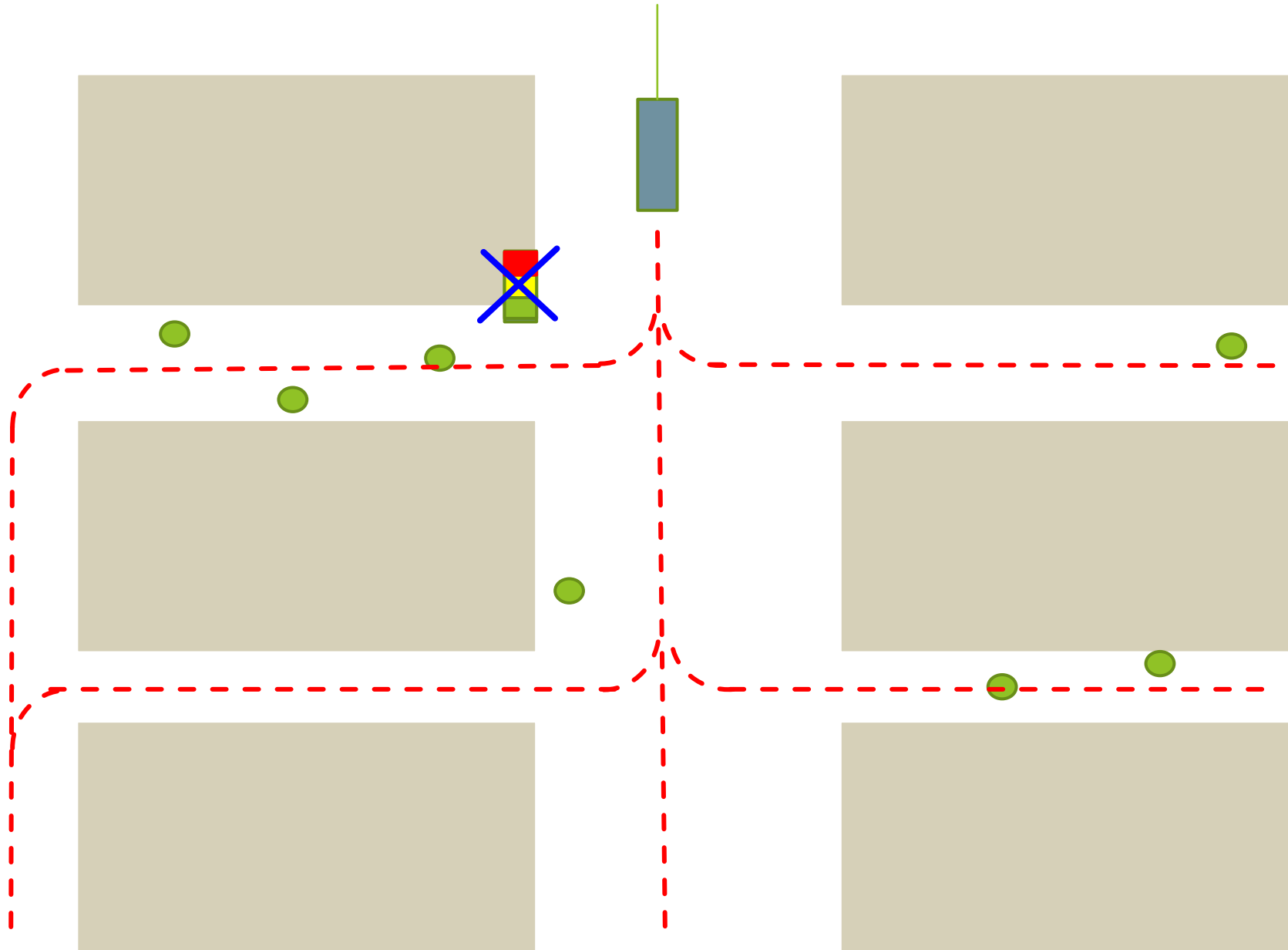Leveson: "Blame the system, not the people"

Current Assets to Utilize

Cameras

AGV's

Systems Integration

Concept Evolution - Camera/AGV Integration

AGV could "see" all possible paths for blockages or humans on a trajectory toward AGV

Determine if AGV was on a collision trajectory towards factory parts, equipment and facilities structures
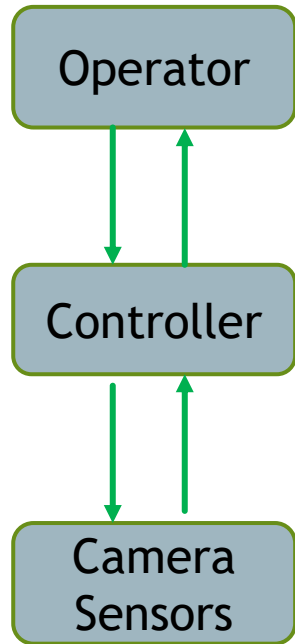
Select or reroute to a path without obstacles and maintain minimum separation distances with objects and humans
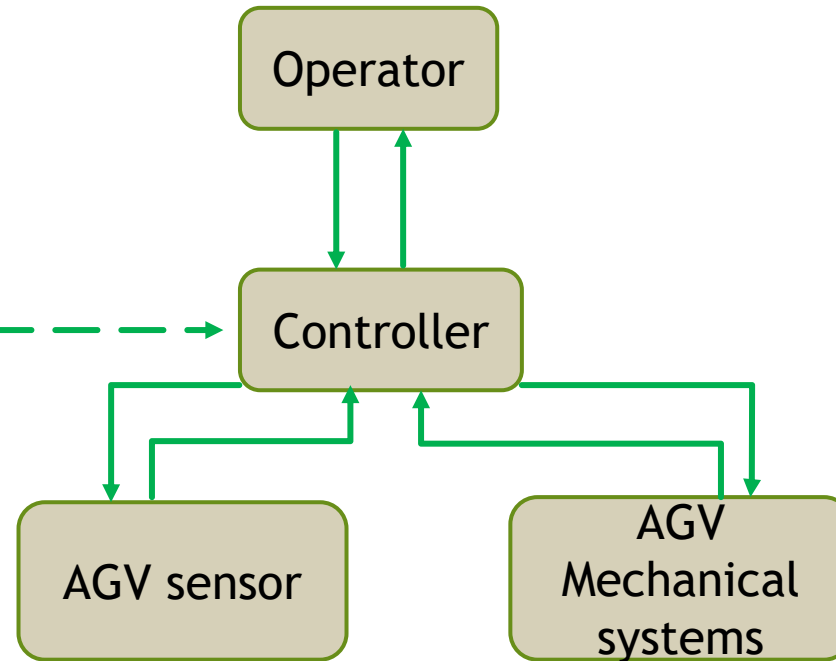
Benefits:
- Removed all AGV delays
- Increased safety and efficiency of the factory
- Increased quality – no damage to parts
- Lower cost operation

STPA Analysis

Camera System

AGV System

Operator

Controller

Camera Sensors

Operator

Controller

AGV sensor

AGV Mechanical systems

Data sent from camera system to AGV system

- Camera data gives location and ID of object in the AGV path
- Decision critical data (reroute, delay or e-stop)
  - Safety, efficiency and quality
- STPA generated 57 requirements for the AGV controller modifications and 21 for the Camera system

Two STPA Examples

- Unsafe Control Action (UCA) and Causal Scenarios (CS)

    - [UCA01] Not providing a STOP command when a person was beyond the range of the sensor results in the collision of a human and the AGV. [H1]

        - [UCA01_CS01] Missing feedback from the AGV sensor to the AGV controller when the person (or object) was outside the sensor field of view caused the process model to think there wasn't anyone in the path when there actually was, resulting in an AGV control action that continued vehicle motion when a person or object was in its path. [UCA_01]

    - [UCA02] Providing a STOP command when one is not needed results in delays in the manufacturing process. [H2]

        - [UCA02_CS01] The camera system provides sensor feedback to the AGV controller with a mis-calculated object location resulting in the AGV process model thinking an object was inside the stopping distance when it actually wasn't. [UCA02]

Summary of Results

People can safely conduct co-located work with AGV's

Reduced cost of manufacturing by eliminating delays, reducing the number of damaged parts and eliminating collisions with humans.

Patent Awarded:
    Case Reference No.: 17-1460-US-CNT
    Publication No.: 2019-0310626 A1
    Title: Multi-sensor Safe Path System for Autonomous Vehicles

For more information contact www.stamp-services.com